IMAGING TEMPERATURE-DEPENDENT FIELD EMISSION FROM CARBON NANOTUBEFILMS: SINGLE - *VERSUS* MULTI-WALLED

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Keywords: Carbon nanotubes, thermionic field emission, field emission microscopy, thermionic emission

Abstract

Fabricating small structures has almost become fashionable in the arena of both the materials science and physics of low dimensional materials. The rationale is that reducing one or more dimensions of a system below some critical length changes the systems' physical properties drastically, where nanocrystalline diamond (n-D) and carbon nanotubes (CNTs) in the class of advanced carbon materials serve model examples [1,2,3]. Emission of electrons at room temperature - cold electron emitters - are of vital importance for a variety of vacuum microelectronic devices - electron microscopes, photo multipliers, X-ray generators, lamps, flat panel displays, and microwave cathodes. Electron emitters may lead to otherwise difficult to obtain advantages in performance and/or design. This is the driving force to investigate the potential of carbon nanotubes as cold cathodes and thermionic power generators.

In this talk, field emission properties of vertically aligned single- and multi-walled carbon nanotube films at temperatures up to 1000 ^{o}C are investigated by electron emission microscopy enabling real time imaging of electron emission to provide information on emission site density, the temporal variation of the emission intensity and insight into the role of adsorbates (see Fig. 1). The nanotube films showed an emission site density of ~ $10^{4\text{-}5}$/cm^2 which is compared to the areal density (from $10^{12\text{-}13}$/cm^2 to $10^{8\text{-}9}$/cm^2). At ambient temperature, the emission indicated temporal fluctuation (~ 6-8 %) in emission current with minimal changes in the emission pattern. At elevated temperatures, the emission site exhibited an increase in emission site intensity (see Fig.2). From the experimental observations it is proposed that the chemisorbed molecules tend to desorb presumably at high applied electric fields (*field-induced*) in combination with thermal effects (*thermal-induced*) and provide a contrasting comparison between semiconducting (single-wall) and metallic (multi-wall) nanotubes.

References

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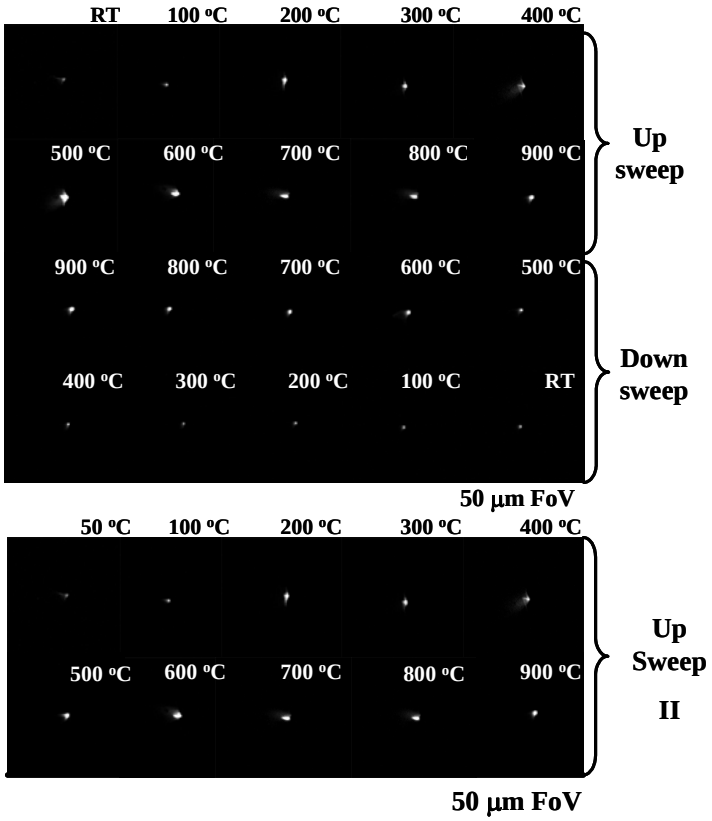

Figure 1. Temperature dependent field emission imaging for a representative multi-wall nanotube film for two warming up (Cycle I and Cycle II) and cooling down cycles. The Cycle II exhibits the thermionic field emission component in addition to field emission.

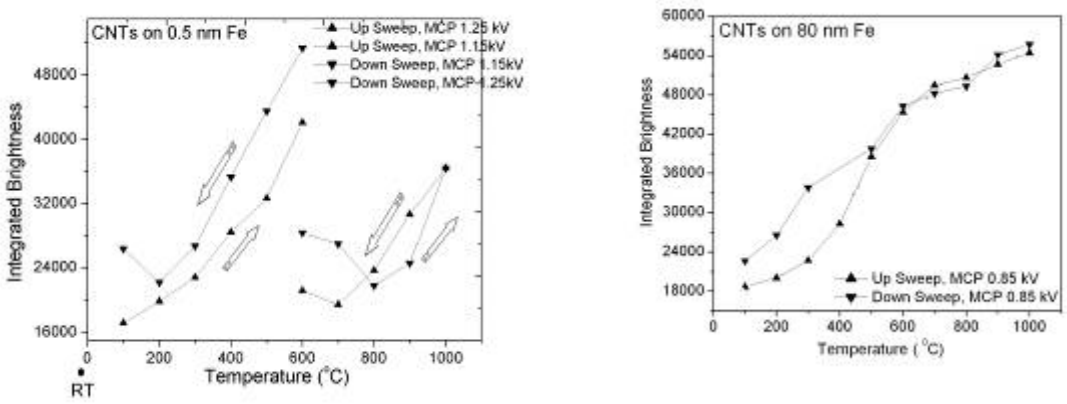

Figure 2. Variation of integrated brightness with temperature (both up and down sweep) for multi-wall nanotube films. The dotted line is used to guide eye and points at the saturation behavior.